by Ruthanne Thompson and Greta Bolin

Indicators of Success in STEM Majors: A Cohort Study

It has become universally known that we as a nation have fallen behind other nations in the areas of science, technology, engineering, and mathematics (STEM). According to the National Science and Engineering Indicators, produced by the National Science Foundation in 2006, the United States has one of the lowest STEM to non-STEM degree rates in the world. In 2002, STEM degrees accounted for only 16.8 percent of all first university degrees awarded in the US. The international average was 26.4 percent, Japan leading with 64 percent and Brazil just below the US with the lowest at 15.5 percent (NSF 2006).

Efforts to combat the well-documented problem have recently taken on a new momentum. In 2005 and 2006 alone, more than six major reports were released by respected academic, scientific and business organizations concerning the need to improve US science, technology, engineering, and mathematics (STEM) education (Kuenzi, 2008). In addition, during these years three bills concerning STEM education were passed into law by the 109th congress and more recently, in 2007 the comprehensive America COMPETES Act was signed into law by the 110th congress (Kuenzi, 2008). The COMPETES act serves to not only expand existing STEM education programs, but also to implement more than 10 new programs to increase the number of students entering STEM disciplines and ultimately, STEM career fields––and it appears that it is working. With all of this attention, and academic and monetary influence directed at trying to better prepare and recruit students into STEM fields, there has been an increase in the number of students enrolling in STEM majors across the country including the emerging research one university used in this study. As one can see from Figure 1, enrollment in STEM disciplines has steadily increased at this university over the last decade with the largest influx concurrent with the legislation and incentives implemented in 2005.

Figure 1. STEM Enrollment Vs. Graduation

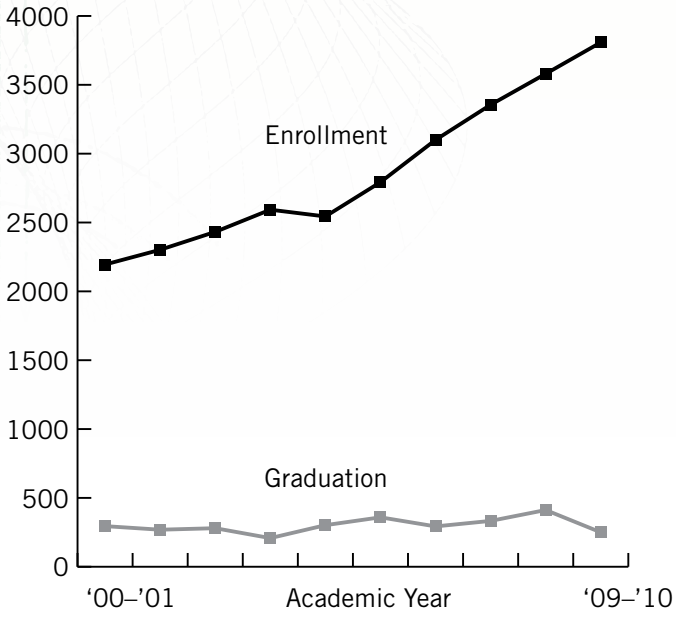


Table 1. STEM Enrollment and Graduation Rates

STEM Students	Mean	SE
Enrollment	2,787	171.3
Graduation	304	19.5
T-test P<.001		

In contrast however, as one can also see in Figure 1 and Table 1, though enrollment in STEM fields is on the rise, graduation is not following suit. These data and current relevant literature led the authors to wonder if there were factors attributed to STEM students who graduated that might serve as predictors or indicators of successful navigation in STEM majors. If factors can be identified, they may be used as tools by high school counselors and college advisors in the recruitment and, possibly more importantly, the *retention* of future STEM students.

Background

In a recent study conducted at a Texas research one university, Scott et al. found a statistically significant correlation between high school rank, combined mathematics and reading SAT scores, and the retention of mathematics and science majors (Scott, Tolson and Huang 2009). The authors, however, went on to suggest that, though the findings were significant, more analysis, specifically disaggregation of the data, should be conducted. Similar to the Scott et al. (2009) study, the current study seeks to determine what factors, if any, might serve as indicators of successful matriculation of first-time freshmen students enrolled in STEM majors in a large emerging public institution in Texas. In contrast to Scott et al. (2009) however, this study seeks to disaggregate the data based on gender, ethnicity, county of origin, and high school ranking, as well as track a cohort of students through a seven-year continuum to determine if the students drop out of the university completely, switch from one major to another and/or graduate. Furthermore, the analysis is conducted for the three largest majors (based on enrollment) at this university, STEM, Business and Education, to determine if the factors are contingent upon the selected major.

Materials and Methods

This study was conducted at a large Texas public institution with more than 28,000 undergraduate students enrolled as of Fall 2009. The study follows a "New From High School" group of students who enrolled at this university in Fall 2003. The total enrollment of this group was 3,618 students. Of these students, 3,451 came from counties within the state of Texas. Enrollment for Full-Time Freshman (FTF) new from high school in 2003 was less than the original 3,618 as 79 New From High School students entered as sophomores and eight entered as juniors and so were excluded from the study. The total FTF enrollment for Fall 2003 was 3,531. (See Table 2 for FTF demographics.)

Table 2. First Time Freshmen Demographics

Gender	
Male	1,585
Female	1,946
Ethnicity	
White	2,447
African American	446
Hispanic	349
Asian/Pacific Islander	243
American Indian/Alaskan	46
Field	
Business	492
Education	418
STEM	490
County	
Dallas	650
Tarrant	625
Denton	491
Collin	272
Harris	254
Other 314 counties	1,239
Rank	
Top 10	702
Next 15 percent	1,061
2nd Quarter	1,319
3rd Quarter	399
Bottom Quarter	50

The sample population (2003 cohort), pulled from this group was comprised of the 1,400 FTF's who declared either a Business (BUS), Education (ED) or Science, Technology, Engineering, and/or Mathematics (STEM) major. This sample population made up 39.6 percent of the total freshman enrollment for 2003. (See Table 3 for complete list of majors included under STEM).

In order to determine if there were factors which could be attributed to students switching majors, dropping out of college or graduating from college, the researchers sought to answer the following questions:

1. Is whether or not a student switches majors, drops out of the university or graduates associated with their original declared major (STEM, BUS, ED)?

2. Is there a relationship between gender and whether or not a student switches majors, drops out of the university or graduates while majoring in a particular field?
3. Is there a relationship between ethnicity and whether or not a student switches majors, drops out of the university or graduates while majoring in a particular field?
4. Is there a relationship between county of origin and whether or not a student switches majors, drops out of the university or graduates while majoring in a particular field?
5. Is there a relationship between high school ranking and whether or not a student switches majors, drops out of the university or graduates while majoring in a particular field?

Chi Square Contingency tests were used to determine associations between independent variables. Chi Square Contingency tests determine if there is an association or relationship between variables (Plackett 1983). If a relationship is found, then you may say that one is dependent on the other. The alpha level was set at 0.05.

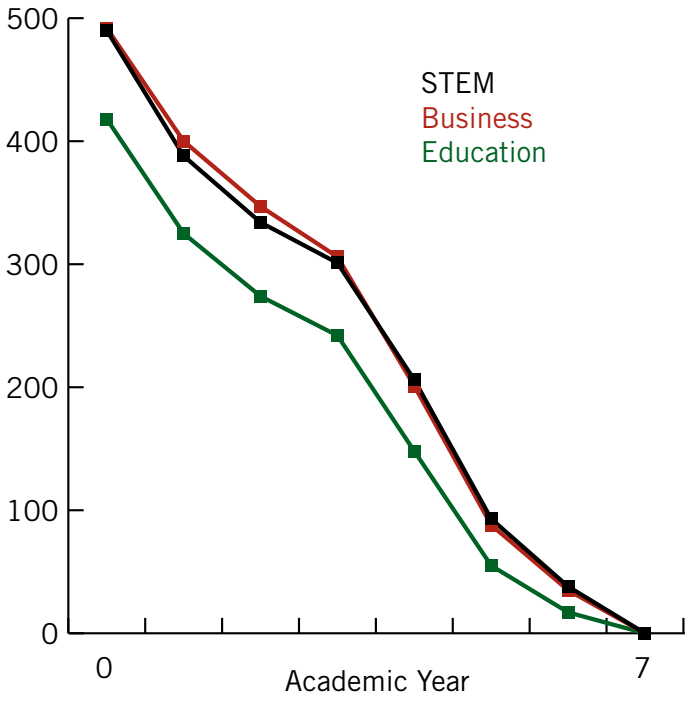
Table 3. Major Plan Description

ATPI-BAAS	Applied Technology & Performance Improvement
BICM-BA	Biochemistry
BICM-BSBC	Biochemistry
BIOL-BA	Biology
BIOL-BSBIO	Biology
BSEP-BSEP	Engineering Physics
CHEM-BA	Chemistry
CHEM-BSCHM	Chemistry
CMPE-BS	Computer Engineering
CNET-BSET	Construction Engineering Technology
CSCI-BA	Computer Science
CSCI-BS	Computer Science
CSIT-BA	Information Technology
EENG-BS	Electrical Engineering
ELET-BSET	Electronics Engineering Technology
ENUN	Engineering Undetermined
INSC-BS	Information Science
MATH-BA	Mathematics
MATH-BSMTH	Mathematics
MEEN-BS	Mechanical and Energy Engineering
MEET-BSET	Mechanical Engineering Technology
MFET-BSET	Manufacturing Engineering Technology
MSEN-BS	Materials Science and Engineering
NUET-BSET	Nuclear Engineering Technology
PBCM	Pre-Biochemistry
PBIO	Pre-Biology
PCIT	Pre-Information Technology
PCMP	Pre-Computer Engineering
PCNT	Pre-Construction Engineering Technology
PCSI	Pre-Computer Science
PEEG	Pre-Electrical Engineering
PELT	Pre-Electronics Engineering Technology
PHYS-BA	Physics
PHYS-BSPHY	Physics
PMEN	Pre-Mechanical and Energy Engineering
PMET	Pre-Mechanical Engineering Technology
PMFT	Pre-Manufacturing Engineering Technology
PMTE	Pre-Materials Science and Engineering
PNUT	Pre-Nuclear Engineering Technology
ATPI-BAAS	Applied Technology & Performance Improvement

Results

In Figure 2, we see how the original cohort of students declines over the seven academic years due to dropping out, switching or graduating for a total of 100 percent of the students engaging in one of the three actions for the three majors.

Figure 2. Total Enrollment for First-Time Freshman Fall 2003



According to the data, whether or not a student switches majors, drops out of college or graduates is associated with their original declared major (STEM, BUS, ED). Whether a person switches

from a particular field or graduates from a specific major is associated with or dependent upon the major the student declared upon entering college in Fall 2003 (Figure 3 and Table 4). The graduation rate for those students starting out as STEM majors was 17 percent compared to Business at 30 percent and Education at 22 percent. In terms of switching majors, 15 percent of Business students switched compared to 27 percent for STEM majors (Figure 4).

Figure 3. Total Number of Graduates by Field and Academic Year

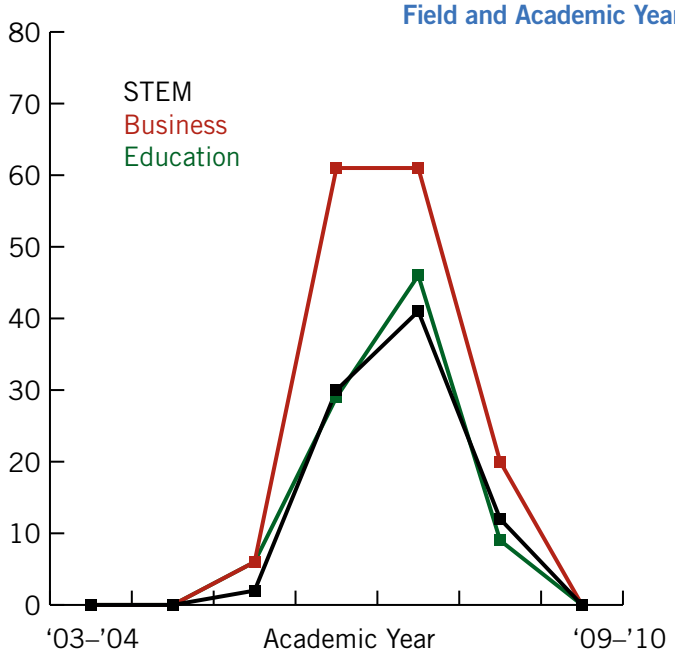


Table 4. Chi Square Contingency Test Results

Variable	Action	Chi Square Contingency Test P Value (α=0.05)
Field Indicator	Switched / Dropped / Graduated	p=0.007 / No Association / p<0.0001
STEM Gender	Switched / Dropped / Graduated	No Association / p=0.028 / No Association
STEM Ethnicity	Switched / Dropped / Graduated	No Association / No Association / p=0.021
STEM County of Origin	Switched / Dropped / Graduated	No Association / No Association / No Association
STEM High School Ranking	Switched / Dropped / Graduated	p=0.003 / p<0.0001 / p=0.007

Gender was associated to the action a STEM major student may take (Figure 5). The number of students who dropped out of school was associated with gender for STEM majors (Table 4). Of the 274 students that dropped out of STEM, 62 percent were male while 38 percent were female.

Figure 4. Fall 2003 Cohort Separated into those who Dropped, Switched or Graduated

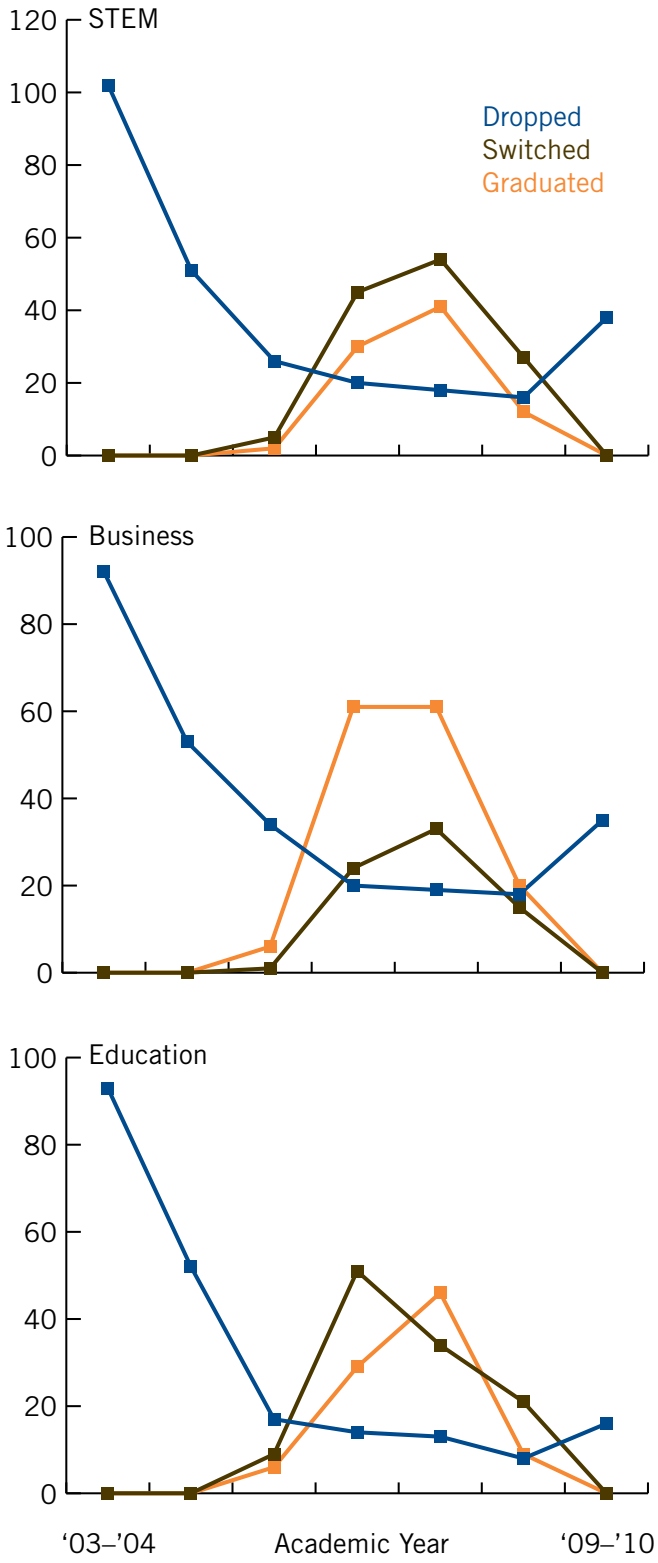


Figure 5. STEM Students Separated by Gender

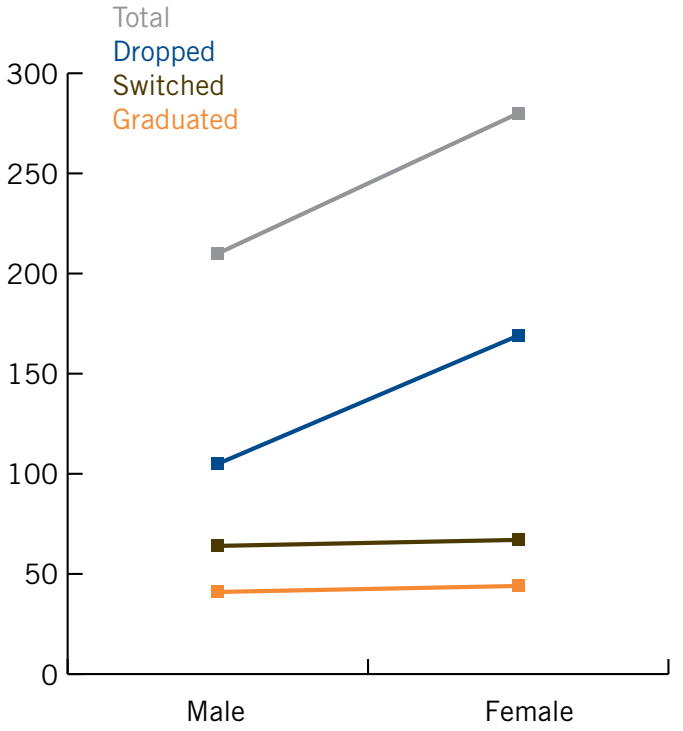
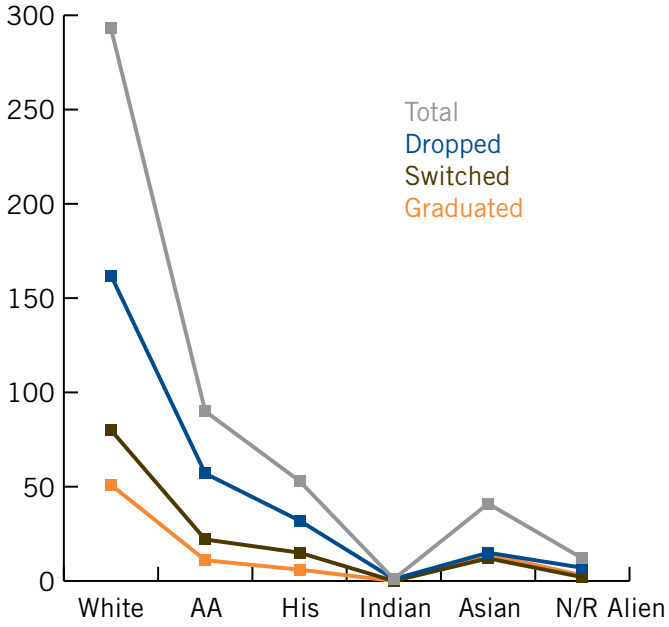


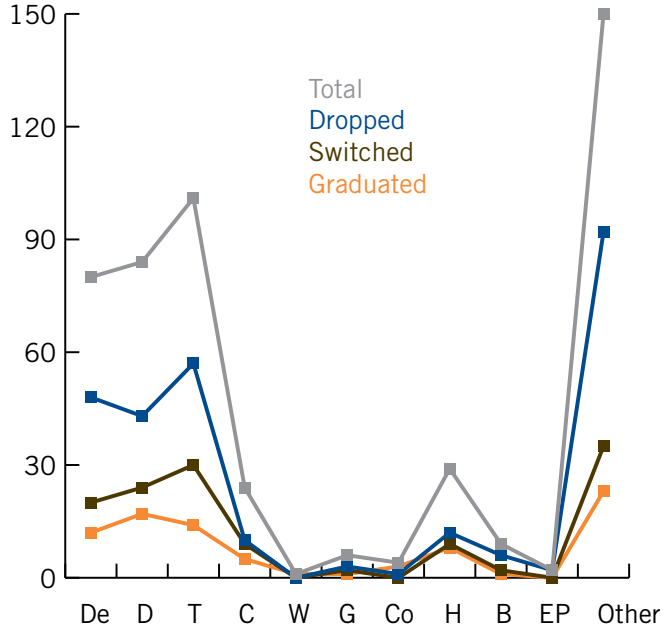
Figure 6. STEM Students Separated by Ethinicity



In addressing Questions 3 and 4, there was no association among dropping or switching and a person's ethnicity and county of origin (Figures 6 and 7). Data showed no statistically significant association between the action a student might take during the seven years examined and their ethnicity and county of origin for those that originally declared STEM majors (Table 3). However, there was an association between ethnicity and whether or not someone graduated in STEM majors (Figure 6 and Table 4). The Asian population showed a 34 percent graduation rate (n=41) while the white, African-American and Hispanic populations showed graduation rates of 17 percent (n=293), 12 percent (n=90) and 11 percent (n=53), respectively.

Finally, there was a relationship between high school ranking and the action a STEM student might take (Figure 8 and 9). The results indicate a statistically significant association between whether or not someone would drop out of college, switch majors or graduate and their high school ranking (Table 4). Of the total STEM cohort that dropped out of college, only 14 percent were in the top 10 percent of their high school class, while 28 percent were in the next 15 percent; 43 percent were in the 2nd quarter and 13 percent in the 3rd quarter and one percent in the low quarter. However, if we look closer at the individual class rankings, a more visible trend arises. Specifically looking at the top 10 percent who originally enrolled in a STEM major,

Figure 7. STEM Students Separated by County of Origin



(n=100), the results demonstrate that 37 percent dropped out of the university completely while 36 percent switched majors and 27 percent graduated. Students in the next 15 percent of their high school class (n=155) suffered a higher dropout rate (48 percent) and lower switch (32 percent) and graduation (20

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percent) rates. Those students from the 2nd quarter (n=165) demonstrated an even higher dropout rate (68 percent) and lower switch (21 percent) and graduation (10 percent) rates. Finally, those students in the 3rd quarter (n=45) had a high (76 percent) dropout rate with 11 percent switch and 13 percent graduation rates while the lowest quarter of students (n=3) had a 100 percent drop out rate from STEM majors. (See Table 4 for p values).

Figure 8. STEM Students Separated by High School Rankings

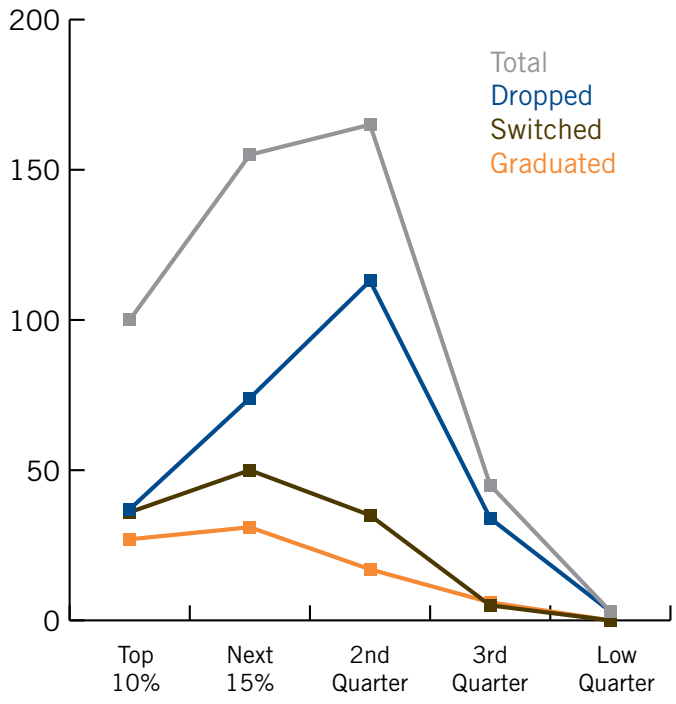
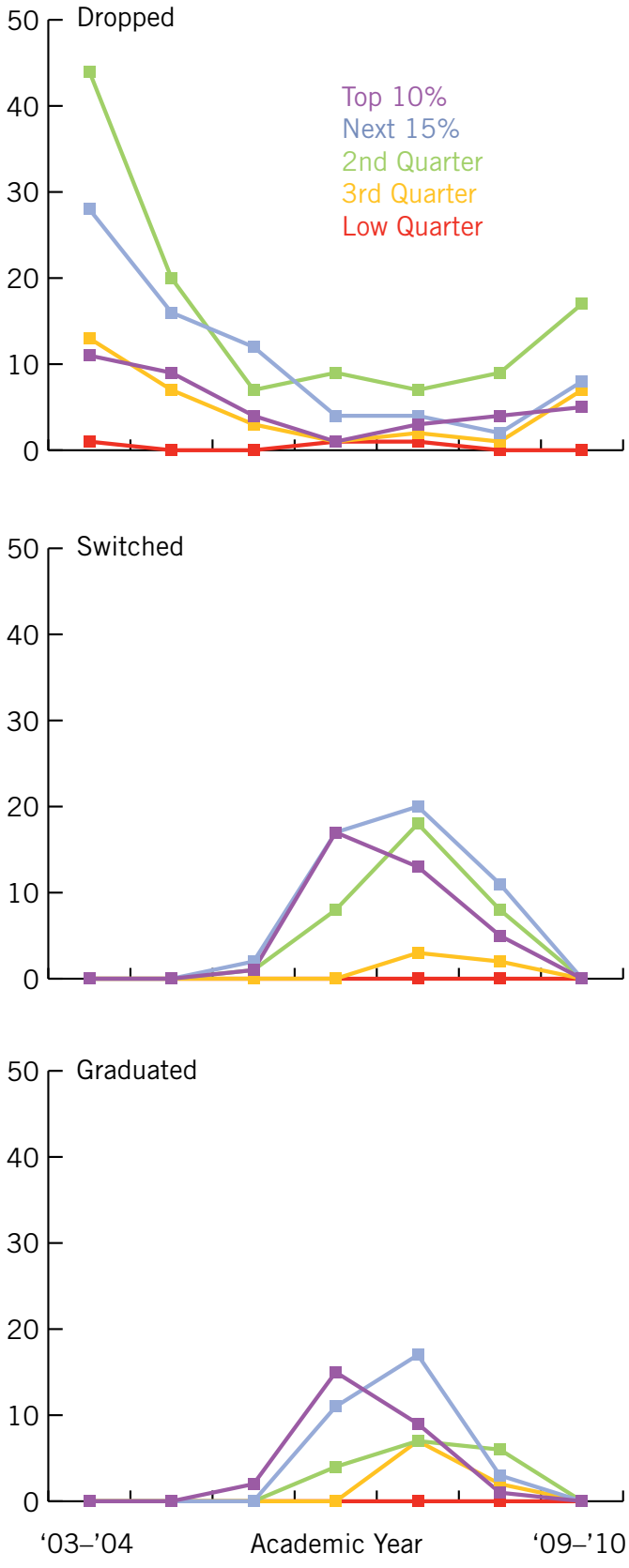


Figure 9. STEM Students Separated by High School Rankings and Action



Discussion

The results confirm what Scott et al. (2009) and others (Astin 1993; Ramist et al. 1993; Tross et al. 2000; Zheng et al. 2002) have found that high school ranking is consistent with predicting matriculation at least for the three majors in this study. For the purpose of recruiting and admission counseling, students with higher high school rankings, no matter their race (Asian population showed the only statistical significance), gender (though females were slightly higher) or which school district they are coming from, should be encouraged into STEM majors. Of course, this does not mean that students with lower rankings will not be successful in STEM majors, but the evidence demonstrates that high school rank is a strong indicator.

Some of the most remarkable findings from this study can be found in comparing Figures 4 and 9. Figure 4 shows similar trends in all three subjects for dropping out of college. The highest numbers of students drop out, from all three subjects, in the first year with significantly less in the second and third years; a somewhat slow but stable rate for the fourth, fifth and sixth years and then a significant increase in drops in year seven. The biggest difference between the three majors is the switch rate. In Business, more students graduated than switched in years four and five; for STEM, more students switched majors in years four and five rather than graduated.

Breaking this down to look at High School Ranking and STEM (Figure 9) specifically, shows that, of the STEM students who switched majors, the largest group was the top 25 percent in year four; and the largest percentage of switches came from the next 15 percent and the second quarter students in year five. With this information, what might be most important to consider is what can be done in the intervening years, between enrollment and graduation, to specifically address the needs of the students before they switch from or drop out of STEM. It appears that recruitment is working at this university, with the data showing a 73 percent increase in enrollment in STEM between the year 2000 and 2010 (Figure 1), while retaining those students through STEM graduation is not working, with an average graduation rate of only 11 percent.

Implications for Future Research

While the findings of this study demonstrate statistical significance, more research should be conducted, specifically addressing the needs of STEM students in years four and five of their program. Both qualitative studies to determine other factors that students perceive as having an impact on their performance and retention in STEM, as well as quantitative studies are needed. Furthermore, implementing and evaluating the effectiveness of an intervention model to mediate the gap between enrollment and graduation in STEM is necessary.

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